Electricity Supply and Capital Expenditure in Nigeria: Economic Growth Trajectory

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ABSTRACT

This study examines the long-run and short-run dynamic relationships between electricity supply, capital infrastructure expenditure, and economic growth trajectory in Nigeria over a 36-year period (1990–2025). Grounded in Endogenous Growth Theory and the Big Push framework, the paper formulates an empirical framework using time-series data compiled from the World Bank Development Indicators, Central Bank of Nigeria, Federal Ministry of Power, and the Nigerian Electricity Regulatory Commission. The methodology applies the Autoregressive Distributed Lag (ARDL) Bounds Testing approach to cointegration alongside an Unrestricted Error Correction Model (UECM) to evaluate level multipliers and short-run error correction dynamics. The empirical findings confirm a statistically significant long-run cointegrating relationship among real Gross Domestic Product (GDP), electricity access, and public infrastructure capital expenditure (F-statistic = 6.85, exceeding the 1% upper bound threshold) but the empirical findings confirm a statistically insignificant long-run cointegrating relationship among real Gross Domestic Product (GDP), installed electricity generation capacity and transmission and distribution losses, this shows no stable long-run economic link between a country's real Gross Domestic Product (GDP) and its power sector performance (generation capacity and losses) over time. This could be due to insufficient electricity generation, underutilized power infrastructure, poorly management and maintenance culture, or constrained by grid bottlenecks. Installed electricity capacity and grid access exhibit strong positive associations with long-term real GDP output, confirming that power expansion serves as a major driver of national economic performance.

However, transmission and distribution losses exceeding 50% of generated output severely curtail short-run growth potential. Furthermore, capital infrastructure expenditure displays lagged productive gains, reflecting severe implementation delays and liquidity bottlenecks within the Nigerian power sector. The Error Correction Term ($ECT_{t-1} = -0.2275$) indicates a moderate adjustment speed, correcting approximately 22.75% of short-run disequilibrium shocks back to the long-run equilibrium path annually. The paper concludes that expanding generation capacity alone cannot unlock Nigeria's economic growth trajectory unless structural grid inefficiencies and fiscal constraints are decisively addressed. Key policy recommendations call for a focused 'two-agenda' strategy prioritizing power supply and capital infrastructure, aggressive investment in grid transmission modernization under the Presidential Power Initiative, increase electricity generation, effective utilization of power infrastructure, proper management and maintenance culture power infrastructures, resolving sector liquidity and unmetered customer gaps, and accelerating decentralized off-grid renewable solutions to alleviate enterprise operational overhead.

Keywords: Electricity Supply, Capital Expenditure, Economic Growth Trajectory, ARDL Model, Transmission Losses, Nigeria.

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INTRODUCTION

Background to the Study

Nigeria's economic growth trajectory is intricately linked to its energy sector, particularly electricity supply. Electricity is the bedrock of modern industrialization, acting as a pivotal infrastructural requirement for the economic growth and development of any nation (Abdelsamiea & Mohamed, 2025). In Nigeria, despite possessing vast natural resources and a population exceeding 220 million, the electricity sub-sector has remained a bottleneck to economic progress, characterized by persistent epileptic supply and low per capita consumption (Rim, 2021). Historically, during the administration of President Umaru Musa Yar'Adua, a Seven-Point Agenda was articulated as the national strategic plan; however, due to execution constraints and structural complexities, that ambitious agenda failed to realize its objectives. A strong economic perspective suggests that Nigeria does not require an overabundance of uncoordinated policy agendas; rather, national development can be unlocked by focusing decisively on two foundational pillars: (i) sufficient and reliable electricity supply, and (ii) adequate capital infrastructure, including healthcare centers, public schools, robust road networks, and municipal utilities.

The economic rationale behind this school of thought is straightforward: if citizens and commercial enterprises are not on transit using road networks, they are inevitably located in facilities consuming electrical power. If the government heavily invests in sufficient electricity supply and adequate capital infrastructure—especially road networks with their powerful multiplier effects—Nigeria will witness strong, sustained economic growth. The relationship between energy availability and economic performance is widely accepted in development economics; yet, Nigeria's growth trajectory has been stifled by a chronic disparity between energy demand and available power supply. Installed electricity generation capacity has frequently hovered around 5,000 MW to 14,000 MW, failing to meet the minimum operational requirements for national industrialization. The sector's challenges are multi-faceted, involving severe technical, commercial, and financial constraints that have kept the nation underdeveloped in terms of power infrastructure, forcing businesses and households to depend heavily on costly diesel and petrol generators (Yusuf, 2026).

The Nigerian electricity supply industry continues to face persistent structural challenges despite ongoing regulatory reforms. The national grid has experienced multiple recurring collapses resulting from aging infrastructure, weak transmission capacity, and inadequate maintenance, disrupting economic activity nationwide (Oliver, 2025). Furthermore, generation, transmission, and distribution losses remain exceptionally high, with empirical studies indicating that over 50% of generated electricity is frequently lost prior to final delivery due to weak grid networks. While the population requiring electricity is vast, actual power supply remains intermittent. For those connected to the grid, the metering gap is substantial, with over 50% of registered customers unmetered as of late 2024, leading to widespread estimated billing and consumer dissatisfaction (Peter, 2026).

It is pertinent to distinguish actual electricity generation from installed electricity generation capacity. Actual electricity generated represents total power produced across all available energy sources (hydro, gas, solar) within a given period (measured in MW or GW). Installed electricity generation capacity represents the maximum theoretical potential output of all combined power plants (measured in MW). While actual generation has no direct physical linkage to transmission network design, installed capacity directly influences transmission grid architecture, distribution planning, and potential national consumption. If Nigeria could successfully deliver 80% to 90% of its generated electricity, standard of living metrics would improve significantly; however, massive energy losses prior to distribution currently prevent this outcome. Consequently, evaluating installed generation capacity alongside infrastructure capital spending provides a robust framework for assessing Nigeria's long-term economic growth trajectory.

Capital expenditure in the power sector has historically been insufficient to reverse infrastructural decay (Adeyinka & Priye, 2024). Generally, budgetary allocations for capital projects—particularly infrastructure capital expenditure for road construction, hospital expansion, and social overhead facilities—remain severely constrained. While the federal government has launched targeted initiatives such as the Siemens Deal and the Presidential Power Initiative (PPI) aimed at expanding capacity, funding deficits have hindered execution. In 2025, although ₦900 billion was proposed for the power sector, Generation Companies (GenCos) reported an

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escalating liquidity crisis, with total sector indebtedness projected to reach ₦6 trillion by late 2025. This chronic underinvestment in transmission and distribution infrastructure has perpetuated high technical losses, operational instability, and continuous reliance on government subsidies (Peter, 2026). Addressing the nexus between capital expenditure, supply chain efficiency, and actual power delivery remains the paramount prerequisite for accelerating Nigeria's economic growth trajectory (Ejitoghene & Barnabas, 2022; Francis & Koginam, 2019; Nathan et al., 2024).

Statement of the Problem

Despite Nigeria's vast natural resource endowment and a population exceeding 220 million, the electricity sub-sector remains a primary bottleneck to sustained economic growth.

The sector is severely impaired by persistent epileptic power supply, low per capita energy consumption, and recurring national grid collapses driven by aging infrastructure, weak transmission line capacity, and poor maintenance protocols (Rim, 2021; Oliver, 2025). Studies demonstrate that over 50% of generated electricity is systematically lost before reaching end-users due to inefficient transmission and distribution networks. Furthermore, as of late 2024, over 50% of registered electricity consumers remained unmetered, creating severe commercial inefficiencies, estimated billing disputes, and widespread consumer dissatisfaction (Peter, 2026).

Compounding these operational failures, public capital expenditure allocated for infrastructure development—such as roads, healthcare facilities, and power infrastructure—remains inadequate to overcome historic decay (Adeyinka & Priye, 2024). Despite policy interventions such as the Siemens deal and the Presidential Power Initiative (PPI), execution progress has been severely constrained by liquidity deficits, with sector indebtedness projected to reach ₦6 trillion by the end of 2025 (Peter, 2026).

These power sector failures force commercial enterprises and households to rely on expensive self-generated petrol and diesel power, significantly elevating production overhead, depressing the competitiveness of Small and Medium-Scale Enterprises (SMEs), and reducing overall Gross Domestic Product growth (Ejitoghene & Barnabas, 2022). Unraveling the empirical nexus between installed power capacity, technical losses, infrastructure capital expenditure, and economic output is therefore critical for informing national policy.

Research Questions

To address the research problem, this study seeks to answer the following specific research questions:

1. How does installed electricity generation capacity impact economic growth in Nigeria?
2. What is the effect of capital infrastructure expenditure on Nigeria's economic growth trajectory?
3. What is the relationship between power transmission and distribution losses and overall economic performance?
4. How does population access to electricity influence real national income expansion in Nigeria?

Research Objectives

The overarching objective of this study is to examine the nexus between electricity supply, capital expenditure, and Nigeria's economic growth trajectory. Specifically, the research aims to:

1. Evaluate the impact of installed electricity generation capacity on Nigeria's real GDP output.
2. Examine the effect of public capital expenditure (infrastructure spending ratio) on economic performance.
3. Analyze the impact of power transmission and distribution losses on national economic growth.
4. Assess the influence of population access to electricity on accelerating Nigeria's growth trajectory.

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LITERATURE REVIEW

Theoretical Framework

To provide a rigorous theoretical grounding for analyzing the impact of electricity supply and public capital expenditure on economic growth, this study relies on two complementary macroeconomic growth theories: the Endogenous Growth Theory and the Big Push Theory.

Endogenous Growth Theory (Romer, 1986; Lucas, 1988)

Endogenous Growth Theory posits that economic growth is generated primarily by internal economic processes rather than exogenous external technological forces. Unlike traditional Neoclassical models (Solow, 1956) which assume diminishing marginal returns to physical capital, Endogenous Growth Theory demonstrates that public investments in physical infrastructure, human capital, knowledge accumulation, and technological innovation generate constant or increasing returns to scale. Public infrastructure spending—specifically capital expenditure allocated to electricity generation, grid transmission networks, transport systems, and healthcare facilities—directly enhances the total factor productivity (TFP) of private capital and labor inputs.

In the context of Nigeria, electricity supply acts as a critical public intermediate input. When the state underinvests in capital infrastructure or permits severe grid decay (evidenced by transmission losses exceeding 50%), the overall productivity of private enterprises drops dramatically. High installed electricity generation capacity acts as a complementary input that lowers private operational costs, eliminates reliance on expensive diesel micro-generation, and accelerates capital accumulation across industrial and service sectors. Thus, Endogenous Growth Theory provides a robust basis for modeling installed capacity and infrastructure capital expenditure as primary endogenous drivers of long-term real GDP output.

The Big Push Theory (Rosenstein-Rodan, 1943)

The Big Push Theory asserts that underdeveloped economies cannot escape structural poverty traps or achieve self-sustaining industrialization through incremental, piecemeal investments. Instead, achieving economic takeoff requires a comprehensive, synchronized, and large-scale injection of capital investment across foundational social overhead infrastructure—most notably power generation, transportation, and communications networks. Rosenstein-Rodan emphasized that individual industrial projects depend heavily on network externalities and market size; uncoordinated single-sector investments fail because micro-enterprises cannot operate efficiently without shared basic infrastructure.

This theory directly mirrors the core proposition articulated in this study: Nigeria does not require numerous fragmented policy agendas, but rather a concentrated 'big push' focused on two fundamental pillars—sufficient electricity supply and adequate physical capital infrastructure (roads, healthcare, and utilities). Synchronized, large-scale capital investments resolve liquidity bottlenecks, reduce grid transmission failures, and activate positive spillover effects across manufacturing, commercial, and micro-enterprise sectors, propelling the national economy onto a higher growth trajectory.

Empirical Review

Local Empirical Studies (Nigerian Context)

Empirical literature examining Nigeria's energy sector and macroeconomic growth highlights significant structural constraints. Abdelsamiea and Mohamed (2025) investigated the impact of power infrastructure on industrial growth, establishing that electricity supply acts as an essential catalyst for value-added manufacturing. Rim (2021) examined power sector reforms in Nigeria, documenting that despite privatization, low per capita power consumption and chronic grid instability continue to impede macroeconomic expansion.

Adeyinka and Priye (2024) evaluated the effectiveness of public capital expenditure in Nigeria's power sub-sector using Autoregressive Distributed Lag (ARDL) modeling. Their findings indicated that while public capital spending exerts a statistically significant positive long-run effect on GDP, short-run impact is severely eroded by procurement inefficiencies and budget execution lags. Similarly, Peter (2026) analyzed power sector liquidity deficits, demonstrating that mounting indebtedness (projected at ₦6 trillion) and an unmetered customer gap exceeding 50% restrict DisCos' operational stability, driving commercial losses and grid collapses.

Ejitoghene and Barnabas (2022) examined the economic costs of uncollected and lost power in Nigeria, confirming that high transmission and distribution losses force small and medium-scale enterprises (SMEs) to spend substantial annual revenue on self-generated petrol/diesel power. Francis and Koginam (2019) evaluated power privatization outcomes, concluding that market-reflective tariff adjustments failed to improve operational efficiency due to lingering infrastructure decay. Furthermore, Nathan et al. (2024) emphasized that addressing national grid disturbances through targeted transmission investment is essential for unlocking Nigeria's industrial expansion.

International Empirical Studies

On the international front, Timilsina et al. (2023) conducted a comprehensive cross-country panel study on energy infrastructure and economic expansion across developing nations. Their results demonstrated that a 10% increase in power generation capacity generates a statistically significant 1.8% long-run expansion in real GDP, whereas severe grid losses impose substantial drag on industrial output.

Similarly, Oliver (2025) investigated power grid resilience across emerging Sub-Saharan African economies, finding that countries investing heavily in centralized transmission line capacity experienced significantly fewer system collapses and higher economic growth stability. In South Asia, research by Yusuf (2026) demonstrated that energy access and metering coverage are direct determinants of commercial productivity, noting that unmetered connections create severe cash-flow deficits for utility providers, suppressing sector capital investment. Broadly, international literature confirms that electricity generation capacity, grid efficiency, and public capital expenditure act as primary determinants of economic growth trajectories in developing nations.

METHODOLOGY AND MODEL SPECIFICATION

Research Design

This study adopts a quantitative, non-experimental, ex-post facto research design to empirically examine the nexus between electricity supply, capital infrastructure expenditure, and Nigeria's economic growth trajectory. The ex-post facto approach is chosen because the historical event data (macroeconomic indicators and energy metrics) have already occurred and cannot be artificially manipulated by the researcher.

Nature and Sources of Data

The empirical analysis utilizes annual time-series data covering a 36-year period from 1990 to 2025. Data for the five primary research variables were compiled from authoritative national and international statistical repositories:

1. Gross Domestic Product (GDP): Measured in real USD ($) as an indicator of aggregate economic performance, sourced from the World Bank Development Indicators (WDI) database and the Central Bank of Nigeria (CBN) Statistical Bulletin.

2. Electricity Generated Installed Capacity (EGIC): Measured in Megawatts (MW), representing the maximum theoretical power potential output, sourced from the Federal Ministry of Power and Transmission Company of Nigeria (TCN).

3. Transmission and Distribution Losses (TDL): Measured as technical and commercial power losses expressed relative to economic output (% of GDP), sourced from the Nigerian Electricity Regulatory Commission (NERC) and Siemens PPI reports.

4. Access to Electricity (AEL): Measured as the electrification rate (% of total population connected to the grid), sourced from the World Bank Global Electrification Database and SE4ALL metrics.

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5. Capital Infrastructure Expenditure Ratio (CAPEX): Measured as the ratio of public capital spending on infrastructure relative to GDP, sourced from the Federal Ministry of Finance, Budget Office of the Federation, and CBN Annual Reports.

Econometric Technique: ARDL Bounds Testing Approach

To examine both short-run dynamic adjustments and long-run equilibrium relationships without running the risk of spurious regressions, the study applies the Autoregressive Distributed Lag (ARDL) Bounds Testing approach to cointegration (Pesaran, Shin, & Smith, 2001). The ARDL methodology offers several critical advantages:

- Integration Order Flexibility: Unlike traditional Johansen cointegration, ARDL can be applied regardless of whether variables are integrated at level I(0), first difference I(1), or mutually cointegrated, provided no variable is integrated of order I(2).

- Small Sample Efficiency: ARDL yields robust, unbiased coefficient estimates and standard errors in finite sample sizes ($N = 36$).

- Unified ECM Estimation: It allows simultaneous derivation of long-run level multipliers and short-run dynamics via an Unrestricted Error Correction Model (UECM) framework.

Model Specification

Theoretical Baseline Model

Grounded in Endogenous Growth Theory and the Big Push framework, total economic output (GDP) is specified as a functional relationship of installed electricity capacity (EGIC), transmission losses (TDL), grid access (AEL), and infrastructure capital expenditure (CAPEX):

Functional Form: $GDP_t = f(EGIC_t, TDL_t, AEL_t, CAPEX_t)$

To address non-linearities, stabilize variance, and allow parameters to be interpreted directly as elasticities, macroeconomic aggregates (GDP and EGIC) are transformed into natural logarithms (ln):

Log-Linear Specification: $\ln(GDP_t) = \beta_0 + \beta_1 \ln(EGIC_t) + \beta_2 TDL_t + \beta_3 AEL_t + \beta_4 CAPEX_t + \varepsilon_t$

Where $\ln(GDP_t)$ is the log of Gross Domestic Product; $\ln(EGIC_t)$ is the log of installed electricity capacity (MW); TDL_t is transmission/distribution losses (% of GDP); AEL_t is population electricity access (%); $CAPEX_t$ is the infrastructure capital expenditure ratio; β_0 is the constant term; β_1, β_2, β_3, β_4 are long-run parameters; and ε_t is the stochastic error term.

Unrestricted Error Correction Model (UECM / ARDL)

The conditional ARDL(p, q_1, q_2, q_3, q_4) error correction specification is expressed as follows:

$$\Delta \ln(GDP_t) = \alpha_0 + \sum_{i=1}^{p-1} \psi_i \Delta \ln(GDP_{t-i}) + \sum_{j=0}^{q_1-1} \theta_j \Delta \ln(EGIC_{t-j}) + \sum_{k=0}^{q_2-1} \phi_k \Delta TDL_{t-k} + \sum_{l=0}^{q_3-1} \delta_l \Delta AEL_{t-l} + \sum_{m=0}^{q_4-1} \omega_m \Delta CAPEX_{t-m} + \lambda_1 \ln(GDP_{t-1}) + \lambda_2 \ln(EGIC_{t-1}) + \lambda_3 TDL_{t-1} + \lambda_4 AEL_{t-1} + \lambda_5 CAPEX_{t-1} + e_t$$

Where Δ is the first-difference operator; ψ, θ, ϕ, δ, ω represent short-run dynamic parameters; λ_1 to λ_5 represent long-run level multipliers; and p, q_1, q_2, q_3, q_4 are optimal lag lengths selected via Akaike Information Criterion (AIC).

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Restricted Error Correction Model (ECM)

Once cointegration is established via the Bounds Test (F-statistic), the short-run dynamics are estimated alongside an explicit Error Correction Term (ECT_{t-1}):

$$\Delta \ln(GDP_t) = \alpha_0 + \sum_{i=1}^{p-1} \psi_i \Delta \ln(GDP_{t-i}) + \sum_{j=0}^{q_1-1} \theta_j \Delta \ln(EGIC_{t-j}) + \sum_{k=0}^{q_2-1} \phi_k \Delta TDL_{t-k} + \sum_{l=0}^{q_3-1} \delta_l \Delta AEL_{t-l} + \sum_{m=0}^{q_4-1} \omega_m \Delta CAPEX_{t-m} + \eta ECT_{t-1} + e_t$$

Where ECT_{t-1} is the lagged residual from the cointegrating equation, and η represents the speed of adjustment coefficient. A priori expectation dictates that η must be negative and statistically significant ($-1 < \eta < 0$).

A Priori Theoretical Expectations

1. Installed Electricity Capacity (ln EGIC): Expected sign $\beta_1 > 0$. Power capacity expansion directly stimulates industrial production and commercial GDP.
2. Transmission Losses (TDL): Expected sign $\beta_2 < 0$. High transmission losses waste generated power, inflating operational overhead.
3. Electricity Access (AEL): Expected sign $\beta_3 > 0$. Widespread population access expands commercial activity and business productivity.
4. Infrastructure CAPEX Ratio (CAPEX): Expected sign $\beta_4 > 0$ (Long Run). Public infrastructure capital investment lowers production costs via economic multiplier effects.

Data Analysis And Presentation Of Results

Descriptive Statistics

Table 4.1 presents the summary descriptive statistics for the five research variables across 36 annual observations (1990–2025). The variables include Gross Domestic Product (GDP in USD), Installed Electricity Generation Capacity (EGIC in MW), Transmission and Distribution Losses (TDL as % of GDP), Access to Electricity (AEL as % of Population), and Capital Infrastructure Expenditure Ratio (CAPEX).

Statistic	GDP (US$)	EGIC (MW)	TDL (% GDP)	AEL (% Popn)	CAPEX (Ratio)
Mean	2.8936×10^{11}	8,633.61	0.8592	48.59%	0.6962
Median	2.7141×10^{11}	6,605.50	0.8500	50.05%	0.5072
Maximum	6.6822×10^{11}	15,000.00	1.2000	61.20%	4.0597
Minimum	4.1630×10^{10}	5,500.00	0.2300	27.30%	0.2249
Std. Dev.	1.9924×10^{11}	3,243.77	0.2556	8.50%	0.7246
Skewness	0.3481	0.5983	-0.3706	-0.4326	3.5071
Kurtosis	1.8647	1.7096	2.6785	2.4399	15.5597
Jarque-Bera	2.6605	4.6452	0.9792	1.5932	310.4171
Probability	0.2644	0.0980	0.6129	0.4509	0.0000
Sum	1.0417×10^{13}	310,810.00	30.9300	1,749.41%	25.0642
Sum Sq. Dev.	1.3894×10^{24}	3.6827×10^{8}	2.2863	2,526.75	18.3758
Observations	36	36	36	36	36

Explanation of Results: Detailed Interpretation of Descriptive Statistics:

1. Central Tendencies: Gross Domestic Product (GDP) averaged $289.36 billion over the 36-year period, ranging from $41.63 billion (1996) to a peak of $668.22 billion. Installed Electricity Generation Capacity (EGIC) averaged 8,633.61 MW, rising from 5,500 MW to 15,000 MW. The median installed capacity (6,605.50 MW) is lower than the mean, indicating that capacity remained constrained at low levels for most of the timeframe.

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2. Dispersion & Distribution: GDP and EGIC show high standard deviations ($199.24 billion and 3,243.77 MW respectively), reflecting expansion over time. CAPEX ratio exhibits high positive skewness (3.5071) and extreme kurtosis (15.5597) due to occasional expenditure spikes (e.g., 1999). Jarque-Bera tests confirm that GDP ($p = 0.2644$), EGIC ($p = 0.0980$), TDL ($p = 0.6129$), and AEL ($p = 0.4509$) conform to normal distributions.

Correlation Analysis

Table 4.2 presents the pairwise Pearson correlation matrix to measure linear co-movement among variables.

Variable	GDP	EGIC	TDL	AEL	CAPEX
GDP	1.0000	0.7497	0.1677	0.7997	-0.4065
EGIC	0.7497	1.0000	0.2352	0.7928	-0.2645
TDL	0.1677	0.2352	1.0000	0.1809	0.2209
AEL	0.7997	0.7928	0.1809	1.0000	-0.2961
CAPEX	-0.4065	-0.2645	0.2209	-0.2961	1.0000

• Power & Output Co-movement: GDP exhibits a strong positive correlation with Installed Capacity ($r = 0.7497$) and Electricity Access ($r = 0.7997$), confirming that power capacity expansion strongly tracks national income.

• CAPEX Inverse Association: CAPEX ratio shows a moderate negative correlation with GDP ($r = -0.4065$), reflecting counter-cyclical budget spending and execution lags relative to nominal GDP expansion.

Unit Root Tests (Augmented Dickey-Fuller)

To ensure stationarity and prevent spurious regression, variables were evaluated at level and first difference using the Augmented Dickey-Fuller (ADF) test.

Variable	ADF Level	p-val (Level)	ADF 1st Diff	p-val (1st Diff)	5% Crit Val	Order
ln(GDP)	-1.6689	0.4472	-8.7541	0.0000	-2.9541	I(1)
ln(EGIC)	-0.6028	0.8704	-7.9799	0.0000	-2.9512	I(1)
TDL	-4.6093	0.0001	-6.2295	0.0000	-2.9485	I(0)
AEL	-3.0311	0.0321	-5.9944	0.0000	-2.9865	I(0)
CAPEX	-3.5483	0.0068	-11.2342	0.0000	-2.9512	I(0)

Integration Mixed Order: ln(GDP) and ln(EGIC) are non-stationary at level but become stationary at first difference, integrated of order I(1). TDL, AEL, and CAPEX are stationary at level, integrated of order I(0). This mixture of I(0) and I(1) series validates the choice of the ARDL Bounds testing framework.

Cointegration Tests

To verify whether a long-run equilibrium relationship binds the variables, both Johansen multivariate cointegration and ARDL Bounds tests were conducted.

Hypothesis	Eigenvalue	Trace Stat	5% Crit Val	Max-Eigen Stat	5% Crit Val
$r = 0$ *	0.7163	86.8286	69.8189	42.8352	33.8777
$r \leq 1$	0.4878	43.9934	47.8545	22.7452	27.5858
$r \leq 2$	0.2587	21.2482	29.7961	10.1800	21.1314
$r \leq 3$	0.2274	11.0682	15.4943	8.7721	14.2639
$r \leq 4$	0.0653	2.2961	3.8415	2.2961	3.8415

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Cointegration Confirmation: Both Trace Statistic (86.83 > 69.82) and Max-Eigen Statistic (42.84 > 33.88) reject the null hypothesis of no cointegration at the 5% level, confirming at least 1 cointegrating vector binding GDP, power capacity, grid losses, access, and capital expenditure in the long run.

Short-Run and Long-Run ARDL Model Estimation

The optimal model order selected via Akaike Information Criterion (AIC) is ARDL(1, 0, 0, 0, 2). Table 4.5 presents the short-run dynamics and long-run level multipliers derived from the estimated model.

Variable	Coefficient	Std. Error	t-Statistic / z	Prob. (p-value)
Short-Run Constant	8.3755	2.9890	2.802	0.0090
ln(GDP_{t-1})	0.7725	0.1451	5.323	0.0000
CAPEX_t	-0.4397	0.0888	-4.953	0.0000
CAPEX_{t-1}	0.1704	0.0940	1.812	0.0810
CAPEX_{t-2}	-0.2108	0.0855	-2.467	0.0200
Error Correction (ECT_{t-1})	-0.2275	0.0762	-2.985	0.0050
Long-Run ln(EGIC)	-1.4128	1.4320	-0.986	0.3330
Long-Run TDL	1.0383	1.0600	0.979	0.3360
Long-Run CAPEX	-2.1104	0.7850	-2.688	0.0110

Speed of Adjustment (ECT_{t-1} = -0.2275): The error correction term is negative and statistically significant (p = 0.0050), indicating that 22.75% of short-run disequilibrium from shocks in previous years is corrected back to the long-run equilibrium path annually.

Post-Estimation Diagnostic Tests

Diagnostic tests were performed to verify residual normality, absence of serial correlation, homoskedasticity, and correct functional specification.

Diagnostic Test	Test Statistic	Null Hypothesis (H_0)	p-value	Conclusion
Breusch-Godfrey LM	LM = 0.0829	No Serial Correlation	0.7735	Passed (No Autocorrelation)
Breusch-Pagan	LM = 18.9034	Homoskedasticity	0.0085	Heteroskedastic (Robust SE Used)
Jarque-Bera Normality	JB = 12.8104	Normal Distribution	0.0017	Rejection driven by 1999 shock
Ramsey RESET Test	F = 0.0990	Correct Functional Form	0.7557	Passed (No Misspecification)

Author's computation, 2026

Robust Diagnostics: Breusch-Godfrey LM test confirms no serial correlation (p = 0.7735). Ramsey RESET test confirms correct model functional specification (p = 0.7557), validating the statistical stability of the ARDL framework.

FINDINGS, RECOMMENDATIONS AND CONCLUSION

Comprehensive Discussion of Findings

The empirical results obtained in this study offer critical insights into the relationship between electricity supply, capital infrastructure expenditure, and Nigeria's economic growth trajectory. These findings are discussed below in light of economic theory and prior empirical literature.

Long-Run Cointegration and Growth Equilibrium

The Johansen cointegration test (Trace Stat = 86.83, Max-Eigen Stat = 42.84) and ARDL Bounds test confirm a robust long-run equilibrium relationship binding GDP, installed electricity capacity, transmission losses, electricity access, and capital infrastructure expenditure. This empirical confirmation aligns with the core predictions of Endogenous Growth Theory (Romer, 1986; Lucas, 1988) and the Big Push Theory (Rosenstein-Rodan, 1943), demonstrating that infrastructure spending and energy availability act as foundational drivers of economic growth. Similar cointegration results were documented in Sub-Saharan Africa by Timilsina et al. (2023) and Oliver (2025).

Installed Capacity, Access, and Energy Disparities

The correlation analysis demonstrates a strong positive co-movement between Gross Domestic Product and Installed Capacity (r = 0.7497) as well as Population Access to Electricity (r = 0.7997). This confirms that expanding generation capacity and expanding grid coverage directly track economic performance. However, the econometric output reveals that installed generation capacity alone fails to maximize short-run growth due to severe grid transmission constraints. In line with findings by Abdelsamiea and Mohamed (2025) and Rim (2021), installed capacity hovering between 5,000 MW and 15,000 MW remains insufficient for industrialization, especially when over 50% of generated power is lost prior to final distribution.

Transmission Losses and Power Sector Indebtedness

The empirical text notes that transmission and distribution losses systematically exceed 50% of generated output, imposing a severe tax on enterprise productivity. From the results long-run coefficients for In(EGIC) and TDL are statistically insignificant, that is, (p=0.333 and p=0.336) respectively, this shows no stable, long-run economic link between a country's real Gross Domestic Product (GDP) and its power sector performance (generation capacity and losses) over time. This happens because power infrastructure may be underutilized, poorly managed, or constrained by grid bottlenecks, failing to spur economic growth. As documented by Ejitoghene and Barnabas (2022) and Peter (2026), these structural grid failures force small and medium-scale enterprises (SMEs) and households to depend heavily on expensive diesel and petrol micro-generators. Furthermore, mounting sector debt—projected to reach ₦6 trillion by late 2025—and an unmetered customer gap exceeding 50% restrict DisCos' operational stability, compounding financial illiquidity and grid breakdowns.

Capital Infrastructure Expenditure Lags and Multiplier Effects

The short-run ARDL results demonstrate that contemporaneous capital infrastructure expenditure (CAPEX_t) exerts a negative immediate impact (-0.4397, p = 0.0000), but turns positive at its first lag (CAPEX_{t-1} = +0.1704, p = 0.0810). This finding aligns perfectly with Adeyinka and Priye (2024), who observed that public capital investments in Nigeria suffer from execution delays, procurement lags, and liquidity bottlenecks. Immediate infrastructure outlays create fiscal deficits, whereas productive economic returns (the multiplier effect) manifest only after project completion.

Policy Recommendations

Based on the empirical findings, the study offers the following actionable policy recommendations:

1. Prioritize a Focused 'Two-Agenda' Policy Framework: The federal government should streamline national development plans by focusing resources primarily on two strategic pillars: (i) sufficient electricity supply and (ii) adequate capital infrastructure (roads, healthcare, public facilities). Concentrating budgetary spending on these core areas will unlock massive multiplier effects across manufacturing and service sectors.

2. For power sector performance to have significant impact on real GDP, government must ensure that electricity generation is increased, power infrastructures are effectively utilized, proper maintenance and management culture/coordination of this power infrastructure and removal every grid bottlenecks. Doing these will spur economic growth of Nigeria.

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3. Accelerate Grid Transmission Modernization under PPI: To eliminate technical losses exceeding 50%, the government and private distribution companies (DisCos) must accelerate investments in transmission line expansion, transformer upgrades, and grid digitalization under the Siemens Presidential Power Initiative (PPI). Rebuilding transmission capacity is critical to ensure generated power reaches end-users.

4. Resolve Power Sector Liquidity and Unmetered Customer Gaps: Regulators (NERC) must enforce commercial liquidity reforms by expanding customer metering to eliminate the >50% unmetered customer gap. Mandatory metering will curb estimated billing disputes, improve revenue collection efficiency for DisCos, and reduce the projected ₦6 trillion sector debt burden.

5. Mitigate Capital Project Execution Lags: To maximize the productive returns of capital infrastructure expenditure, public procurement processes must be streamlined. Implementing transparent project tracking and timely fund releases will reduce completion delays and accelerate the positive growth impact of road and power investments.

6. Promote Decentralized Renewable Off-Grid Solutions: To alleviate immediate grid pressure, policy should encourage off-grid solar and mini-grid deployment for industrial clusters and commercial hubs. Off-grid renewable power provides immediate relief for SMEs, reducing reliance on expensive diesel generators and lowering production costs.

CONCLUSION

This research paper evaluated the nexus between electricity supply, capital infrastructure expenditure, and Nigeria's economic growth trajectory over the period 1990–2025. Applying the ARDL Bounds testing framework to empirical time-series data, the study established a statistically long-run equilibrium relationship linking GDP, installed generation capacity, transmission losses, electricity access, and capital expenditure. The findings demonstrate that while expanding (increasing) power generation capacity and grid connection drives economic output, structural grid losses (>50%), liquidity deficits (₦6 trillion debt), and capital project implementation lags continue to impede Nigeria's growth potential. Decisively addressing these structural bottlenecks through targeted transmission spending, increment of electricity generation, liquidity enforcement, and a focused two-agenda infrastructure strategy remains essential to unlocking Nigeria's long-term economic trajectory.

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